BRUSH Instruments

BRUSH

Dual Channel D-C Amplifier

MODEL BL-928

OPERATING INSTRUCTIONS

BRUSH ELECTRONICS COMPANY
Formerly
THE BRUSH DEVELOPMENT CO.
3405 PERKINS AVENUE • • CLEVELAND 14, OHIO

THE BRUSH DEVELOPMENT COMPANY

Instrument Division

MANUFACTURERS OF...

- ★ *Direct Inking Oscillographs*
- ★ *AC Amplifiers*
- ★ *DC Amplifiers*
- ★ *Carrier Amplifiers*
- ★ *Surface Analyzers*
- ★ *Universal Analyzers*
- ★ *Contour and Displacement Analyzers*
- ★ *Strain Analyzers*
- ★ *Uniformity Analyzers*
- ★ *Universal Bridge Switches*
- ★ *Regulated Frequency Power Supplies*
- ★ *WOW Meters*
- ★ *Vibration Pickups*

and other acoustic and electronic instruments

Dual Channel D-C Amplifier MODEL BL-928

OPERATING INSTRUCTIONS

F#670-5M-7-51

OPERATING INSTRUCTIONS

Dual Channel D-C Amplifier

MODEL BL-928

GENERAL DESCRIPTION

Dual Channel D-C Amplifier Model BL-928 is a moderate gain amplifier designed primarily for use with Brush Magnetic Direct Inking Double Channel Oscillographs. It provides in compact form a means of measuring and recording two simultaneous electrical phenomena of potential of 50 millivolts or more and frequency components between zero and 100 cycles.

The Model BL-928 is particularly useful in the study of battery characteristics, photocell outputs, electrolysis surveys and characteristics of d-c generators and motors. Used with slow speed chart oscillograph, the amplifier is invaluable as a trouble-shooting instrument, for example, in locating intermittent faults in electronic devices.

The Model BL-928 consists of two, separate, three stage, direct-coupled amplifiers, a dual calibrating circuit with a standard cell to provide a d-c calibrating voltage and a regulated power supply for 95 to 125 volts, 60 cycle operation. Oscillograph pen drift is held to 0.25 mm an hour or less by use of a Sola voltage regulating filament transformer and VR tubes in the high voltage power supply to compensate for power line variations.

Each channel has its individual VR tubes to minimize possibility of cross modulation between amplifying units. To provide adequate $B^{\pm}$ power without excessive heat, a single transformer and selenium rectifiers operate as a voltage doubling circuit with midpoint at ground potential.

The top panel of the Model BL-928 contains separate input terminals and operating controls for each of the two amplifier channels. These controls are Calibration button, D.C. Center for centering the oscillograph pen, gain and attenuator knobs. Figure 2 shows the power and output and input connections between the amplifier and Brush Oscillograph Model BL-202.

The amplifier case can be slipped off by removing screws from the bottom and input terminal screw plugs from the top. Four rubber feet have been mounted on the back plate of the chassis so that the amplifier can be conveniently placed on end for servicing.

When ordered in combination, amplifier and oscillograph are calibrated together at the factory for uniform frequency response. This response for such a matched amplifier-oscillograph combination is constant within less than 5% from d-c to 100 cps. If ordered separately, the amplifier can be adjusted for use with another penmotor as explained under Alignment in this operating manual.

Sensitivity of the Model BL-928 Amplifier when used with a Brush oscillograph is one millimeter of pen deflection per 50 millivolts input. Maximum pen deflection is obtained with voltages as low as 1 volt

Figure 1 - The Model BL-928 Amplifier.

or as high as 200 volts by use of the attenuator.

Frequency response of the pen limits the amplitude of deflection which can be used. For signals up to 60 cps, the pen can be safely driven to a maximum deflection of 20 millimeters either side of center or 40 millimeters overall. For signals from 60 cps to 100 cps, the practical working range of the pen is about 10 millimeters either side of center. Values obtained for a-c input signals are instantaneous or peak reading.

Because both channels of the Model BL-928 Amplifier have a common ground, it cannot be used in applications having separate and different ground levels.

SETTING UP

The amplifier can be connected directly to double channel oscillographs such as the Models BL-202 or BL-222. With the power switches of both instruments at the OFF position, the connections to be made between the amplifier and oscillograph are:

Power cable from 115 volt, 60 cycle supply to amplifier;

Power cable from amplifier to oscillograph;

Cables from the two four-prong female connectors (output) on the back of the amplifier to the two input terminals of the oscillograph. See Figure 2.

In case, the amplifier is to be used with penmotors alone, exclusive of the oscillograph paper driver, penmotor leads should be connected to prongs numbers 1 and 3 or 4 of the four-prong male collectors on the cables furnished with the Model BL-928.

Although grounding the amplifier chassis is not always necessary from an operational standpoint, it

BRUSH ELECTRONICS COMPANY

Parts List

BL 928 Amplifier

Date: August 1, 1953

Symbol	Parts Number	Description
C-1	102711	Capacitor, 20-20 mfd. 450 V
C-2	106743-5	Capacitor, 20 mfd. 450 V
C-3	113589-106	Capacitor, fixed 10 mfd. 25 V
C-4, C-7	20-112034-472	Capacitor, .0047 mfd. 600 V
C-5, C-8	20-112034-103	Capacitor, .01 mfd. 600 V
C-6, C-9, C-10	105095-10	Capacitor, 2x1 mfd. 600 V
C-11, C-12, C-13		
C-14	114311-806	Capacitor, 80 mfd. 450 V
F-1	102625	Fuse, type "3AG"- 2 amps
R-3, R-4	5-113038-402	Resistor, fixed 4K 20 W
R-5, R-6	5-115557-101	Resistor, 100 ohm ½ W
R-7	5-115557-223	Resistor, 22K ½ W
R-8	5-115557-514	Resistor, 510K ½ W
R-10, R-25	113432	Resistor, variable-Linear taper-10 meg.
R-11, R-26	2-106620-27	Resistor, 1000 ohm ½ W
R-12, R-27	2-106620-28	Resistor, 800K ½ W
R-13, R-14, R-28 R-29	2-106620-2	Resistor, 1 meg. ½ W
R-15, R-60	2-106620-29	Resistor, 680K ½ W
R-16, R-17, R-30 R-36	5-115557-334	Resistor, 330K ½ W
R-18, R-32	5-115559-123	Resistor, 12K 2 W
R-19, R-33	103282	Potentiometer 3000 ohm 3 W WW
R-20, R-34	5-115559-513	Resistor, 51K 2 W
R-22, R-36	5-115557-682	Resistor, fixed 6.8K ½ W
R-23, R-37	102749	Resistor, Variable 10K 3 W
R-24	5-115557-103	Resistor, 10K ½ W
R-44	2-106620-21	Resistor, 5 meg. ½ W
R-45	1-112244-905	Resistor, 9 meg. 1 W
R-46	1-112244-955	Resistor, 9.5 meg. 1 W
R-47	2-106620-25	Resistor, 425K ½ W
R-48, R-49	2-106620-26	Resistor, 50.5K ½ W
R-50, R-51	1-112244-154	Resistor, fixed 150K 1 W
R-52, R-53, R-54, R-55	5-115557-243	Resistor, fixed 24K ½ W
R-58	1-112244-106	Resistor, 10 meg. 1 W
R-59	2-106620-23	Resistor, 1.1 Meg. ½ W
R-61	5-115557-204	Resistor, fixed 200K ½ W
R-62, R-63	5-115557-153	Resistor, 15K ½ W
S-1	102842	Switch, Toggle - SPST
SR-1, SR-2, SR-3, SR-4, SR-5, SR-6 SR-7, SR-8	111031	Rectifier, Metallic
T-1	104622	Transformer, Constant Voltage
T-2	209726	Transformer, Power
T-3, T-4	9524	Choke

Symbol	Part Number	Description
V-1, V-2, V-4, V-5	102708	Tube, Electron 6F5
V-3, V-6	102709	Tube, Electron 6V6
V-7, V-8, V-9, V-10	102706	Tube, Electron-#0D3/VR150
	400174	Case Ass'y, Amplifier
	201376	Handle, Case
	102168-1	Connector, Receptacle-Female Contact-8 Prong.
	209728	Shield, Power Supply
	204988	Panel, Control
	109731-501	Attenuator, Ass'y
	109792	Switch, Rotary
	9536	Switch, Push Button
	6526	Socket, Motor Base
	102168-3	Connector, Receptacle-Female Contact-4 Prong
	9543	Plate, Switch Indicator
	102157	Socket, Tube Replacement-8 Contact
	9539	Post, Fuse
	109723	Panel, Engraved-Control #2
	103046	Post, Binding
	103078	Insulator, Standoff-Paired
	9577	Knob
	109682-2	Button, Push
	105853	Bracket, Pilot Light
	1-104326-2	Jewel, Pilot Light
	1-105796-1	Lamp, Mazda-Incandescent
	109833	Button, Push-Modified
	2-112472-4	Clip, Grid
	3-113294-89	Button, Plug
	113527-501	Rectifier Ass'y
	111111-103	Resistor, Fixed 10K 10W
	111111-602	Resistor, Fixed 6K 10 W
	213530-501	Cell Ass'y
	109807	Cell, Voltage Standard
	109721	Case, Standard Cell

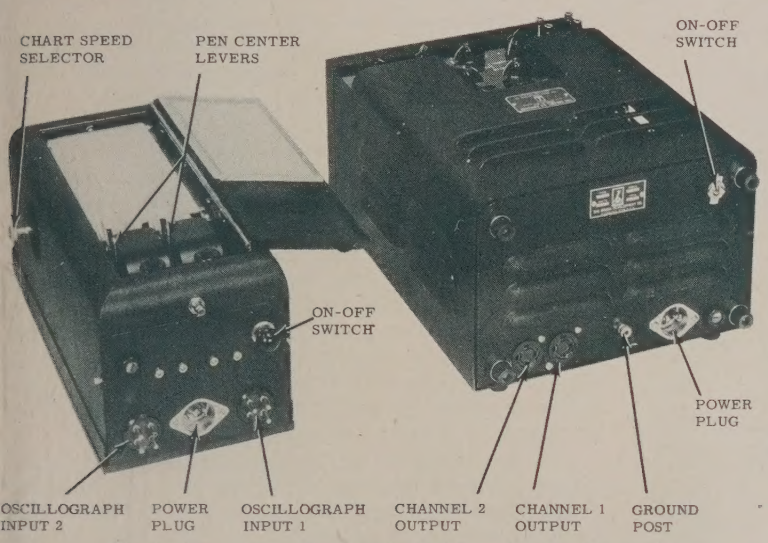


Figure 2 - Rear View, Model BL-202 Oscillograph and BL-928 Amplifier.

is an advisable precaution. A binding post is provided on the back of the amplifier for the purpose.

ADJUSTMENT

With both attenuator controls at the OFF position, turn on the power and allow the amplifier 15 minutes to warm up. Center pens of the oscillograph mechanically by means of the pen center levers (Figure 2). Turn on the oscillograph and chart drive motor. Set the drive at slow speed (selector rod on side of oscillograph all the way in, Figure 2). Center the pens precisely by adjustment of the amplifier's D-C Center controls.

Center is the normal pen position for recording impulses of both positive and negative signs. When impulses of one polarity only are to be recorded, it may be advantageous to bias the pens to an extreme position on the chart in order to make full use of the entire range of pen deflection. This should be done by applying a bucking voltage to the amplifier inputs. Attempting to bias the pens more than 5 millimeters off center by means of the D-C Center controls will produce non-linear response. A service bulletin on bucking techniques is available on request.

As explained under Calibration, the proportion of pen deflection to input can be adjusted as desired by means of the gain control and calibrating circuit of the amplifier.

OPERATION

Input is supplied to the amplifier through the four binding posts located at the left corner of the control panel. However, before applying any input voltage, it is important that the attenuator knobs be turned to OFF (minimum sensitivity). Otherwise, the risk is run of causing a pen to jump out of its support with possible damage to it.

For this same reason, it is a wise precaution to start all measurements of unknown voltages with the attenuators set on the "10" taps, then decrease the setting (increasing sensitivity) to a maximum pen displacement not exceeding 20 millimeters either side of center or 40 millimeters in all.

Fine sensitivity adjustments are made by means of the gain controls on the amplifier. It will be noted that by reducing the gain, sensitivity can be decreased to any desired level regardless of the attenuator setting. But the recommended procedure is to operate the amplifier with the attenuator set at a position consistent with the magnitude of the input signal. Use of the gain control is then limited to the final, precise adjustment to the desired level of sensitivity.

CALIBRATION

Each channel of the amplifier must be individually calibrated. Pressing the button marked Calibrate on either of the two channels impresses a voltage of one volt d-c from a standard cell on the input of that channel. The channel may then be calibrated for maximum sensitivity by adjusting the gain until the pen is deflected 20 millimeters from center, that is one millimeter for every 50 millivolts of input. At this calibration, attenuator settings are direct reading in volts per line. For example, at the .5 position, every half volt of input will deflect the pen one line. Thus an unknown input voltage can be determined by multiplying the number of lines of pen deflection by the attenuator setting. On the .5 scale, 18 lines of pen deflection would indicate 9 volts input. On the 10 scale, 18 lines deflection would indicate 180 volts input.

However, it is of course possible to calibrate the amplifier for sensitivity less than 20 lines pen deflection at the one volt calibrating voltage. In this case, attenuator values are not direct reading, and unknown input voltages are determined by the product of the attenuator setting, lines of pen deflection AND the calibration in v/line. For example, suppose the gain were adjusted for 10 lines deflection at the one volt calibrating voltage. The calibration would then be 2v/mm. And 18 lines pen deflection at an attenuator setting of .5 would equal .5 x 18 x 2 or 18 volts input.

ELIMINATING PEN OVERSHOOT

At the factory, the Model BL-928 Amplifier is aligned with an oscillograph for the most uniform response from d-c to 80 cps. This provides the most useful operating range for general purpose work where both steady state and dynamic signals of moderate frequencies are encountered.

However, in special applications such as recording square waves and step functions, minimizing pen overshoot becomes essential and this can be accomplished by a slight change in the frequency response of the amplifier. The adjustment, taking one channel at a time, is performed as follows:

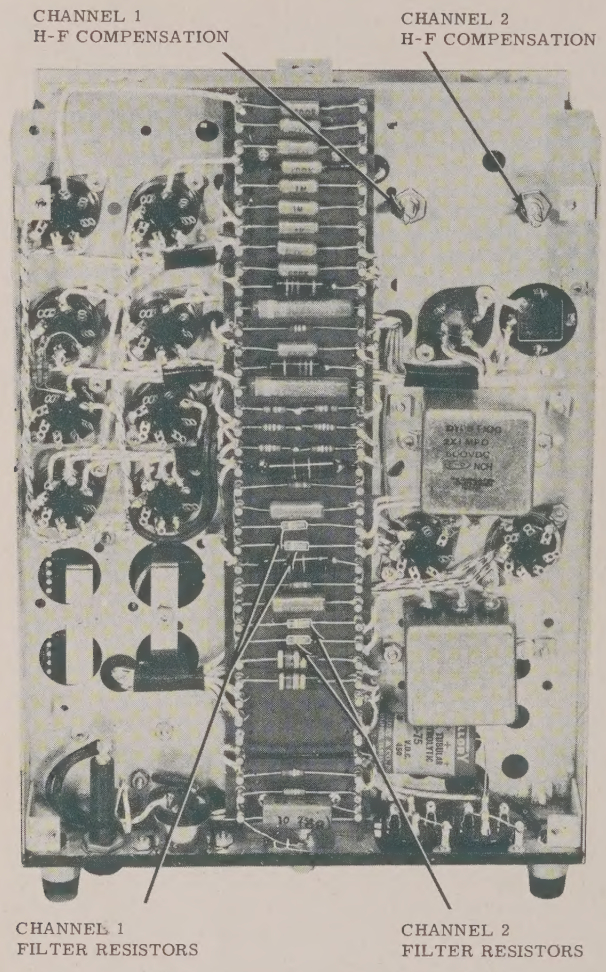


Figure 3 Bottom View, BL-928 Amplifier.

1. Apply a known voltage at 20 cps and adjust the gain until a pen deflection of 10 lines overall is produced.
2. Substitute an input of the same voltage but at 80 cycles and adjust the High Frequency Compensation control (slotted shaft, opening for screwdriver, Figure 3) until the pen is deflected about 7.5 lines.
3. Repeat steps 1 and 2 until the 20 cps signal produces the 10 line trace and the 80 cps signal, the 7.5 line trace without need of further adjustment at either frequency.

ALIGNMENT WITH UNMATCHED PENMOTOR

Characteristics of penmotors may vary and if a motor or oscillograph strange to the amplifier is used, a frequency check should be made. Procedure is similar to that followed in eliminating pen overshoot, as described in the previous section. However, this time the 20 and 80 cps signals should produce equal band widths of 10 mm when the gain and High Frequency Compensation are properly adjusted.

One further adjustment of the amplifier to a previously unmatched penmotor or oscillograph will be required if it is found that response in the neighborhood of 2 cps is outside the normal limits of 9-1/2 to 10-1/2 lines. This is corrected by adding or removing sections of the feedback loop filter in either or both channels, as the case may be, since relative response at 2 cps is in inverse proportion to the amount of filter in the circuit.

If the amplifier case is removed and the chassis placed on end on the four rubber feet provided for the purpose, the two filter section resistors of Channel 1 will be found on terminals 15 and 16 counting from the bottom of the long terminal board which runs lengthwise along the bottom of the amplifier. The corresponding Channel 2 resistors will be found on terminals 10 and 11. (See Figure 3).

Relative response in Channel 1 is lowered by connecting the free terminal of one (or both, as required) of its filter resistors to Terminal 17. Relative response in Channel 1 is increased by disconnecting one or both resistors from Terminal 17. Similar connections or disconnections of the Channel 2 filter resistors, with similar effect, are made at Terminal 12.

At the factory, filter sections in each channel were inserted or omitted according to the arrangement which produced the best response with the oscillograph used for alignment at that time.

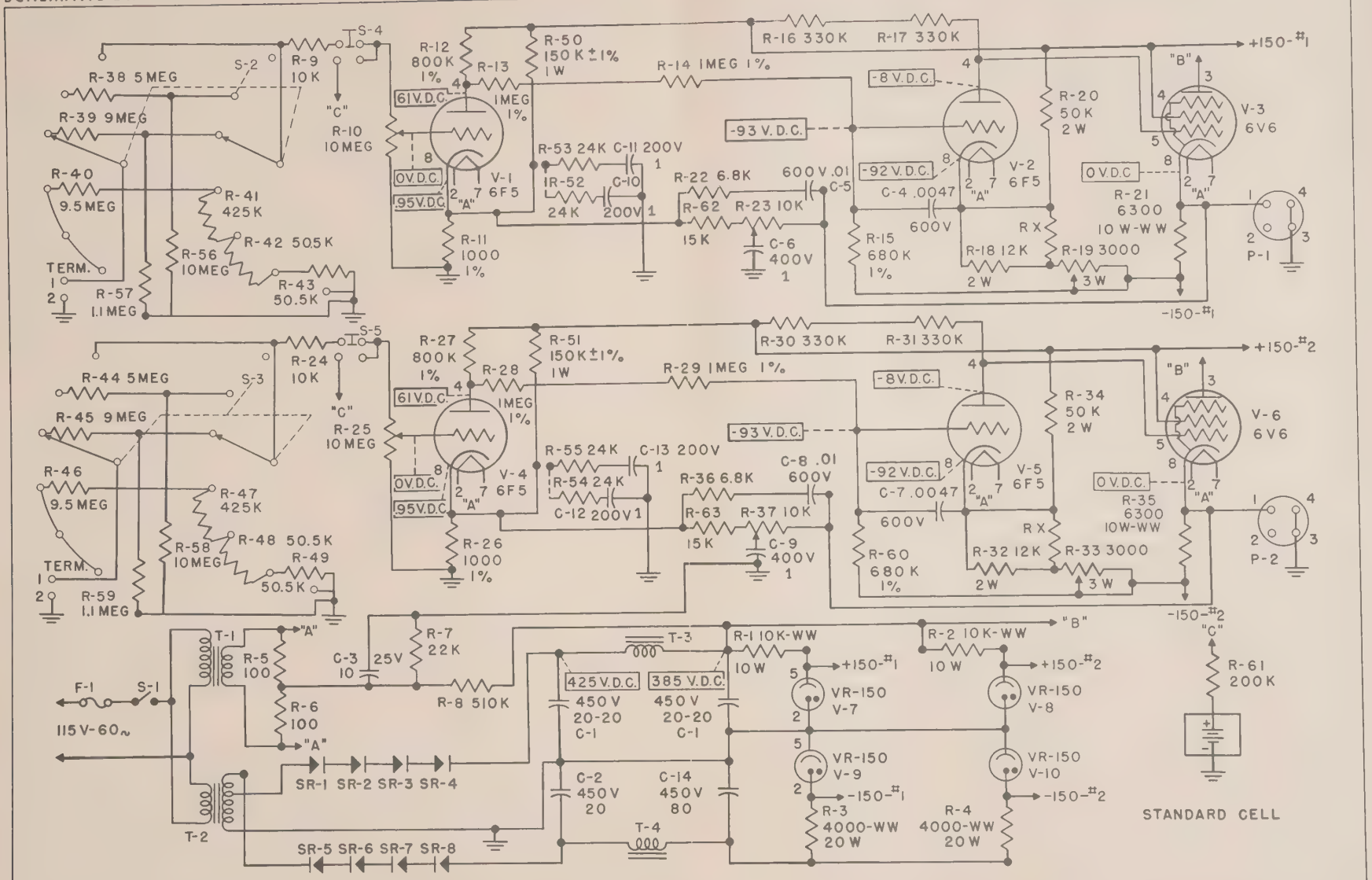
MAINTENANCE

Information needed for servicing the Model BL-928 Amplifier is provided in the schematic diagram furnished with each unit. This shows circuit connections, static and operating voltages and values of components. Tube positions are marked on the chassis. The circuits are not critical and therefore do not require matched tubes or other special components. Replacement may be made with any standard types from stock.

SPECIFICATIONS:

MODEL BL-928 DUAL CHANNEL D-C AMPLIFIER

Input voltage range -- 0.05 to 200 volts
Output voltage -- 15 volts (max. RMS)
Input impedance -- 10 megohms
Output impedance -- approximately 50 ohms (not to be loaded with less than 1,500 ohms)
Power required -- 95 to 125 volts, 60 cycles, 145 watts
Dimensions -- 17" long x 11" wide x 7" high
Net weight -- 30 pounds
Shipping weight -- 34 pounds
Tubes required -- Four 6F5, two 6V6GT, four VR-150
Fuse -- 2 ampere "Littelfuse" type 3 AG or equivalent.
Frequency response of amplifier and oscillograph -- 0 to 100 cps
Sensitivity -- 1 chart mm per 50 mv
Stability -- 0.25 mm pen drift or less per hour
Voltage gain -- 25 times (approx.)



1. All D-C Voltages measured with respect to chassis taken with Volt Ohmyst Jr. V.T.V.M. (11 Meg. input)

2. Rx and Ry are to be of such values as to permit the Balance controls to produce equal deflections on each side of center.

HANDY INDEX

To make it easier for you to use this booklet, Brush Instruments are grouped according to the types of jobs they do. For example, if your problem concerns surface finish, just turn to the section "Surface Analysis." Here you will find two types of surface-analyzing instruments.

It is not possible in this booklet to give all available information on each instrument. If you want complete data or recommendations on certain equipment, just send one of the convenient reply forms at the back of this booklet.

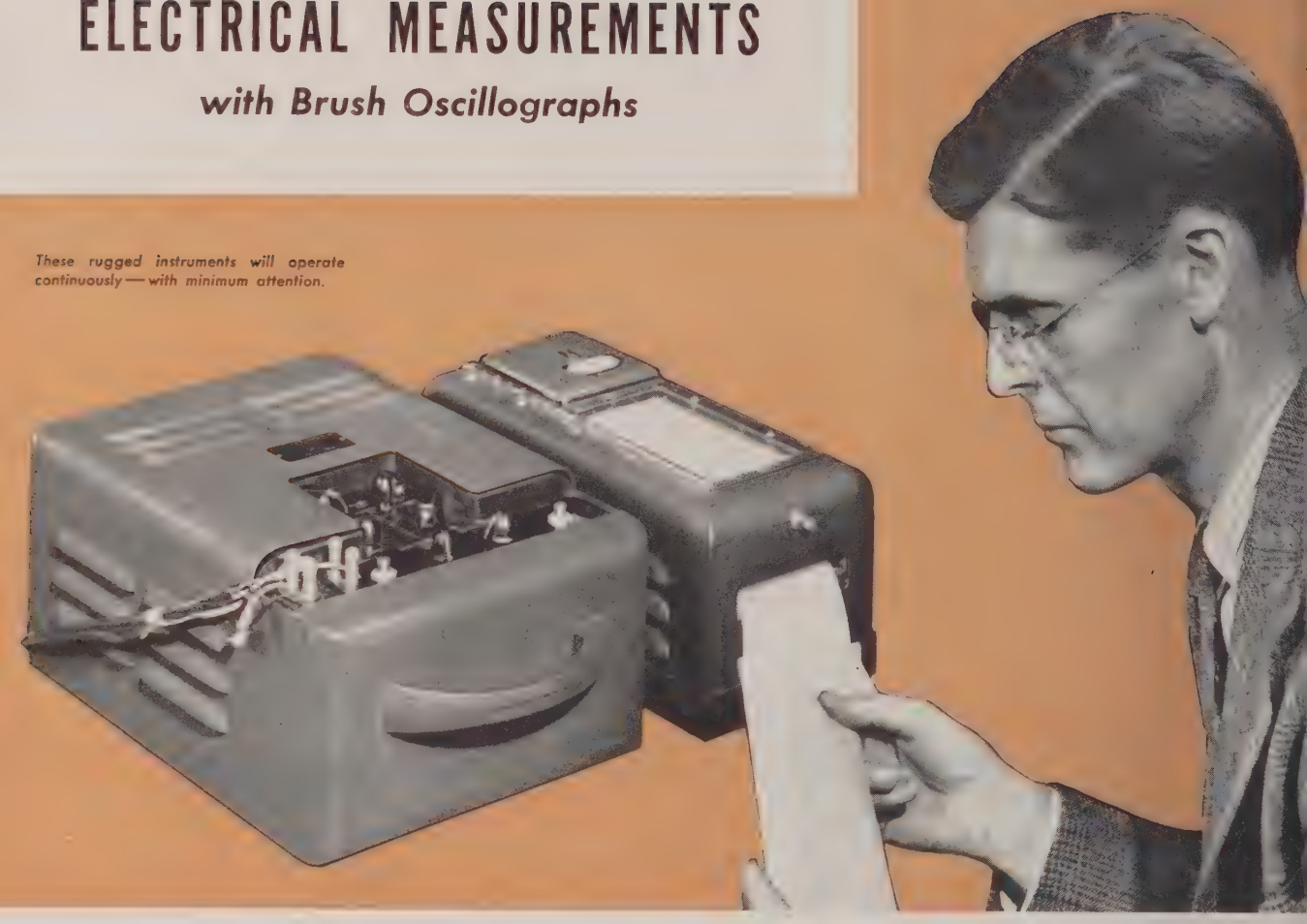
- ELECTRICAL MEASUREMENTS
- PHYSICAL MEASUREMENTS
- SURFACE MEASUREMENTS
- RESISTANCE-WELDING MEASUREMENTS
- TEXTILE MEASUREMENTS
- ULTRASONIC ENERGY APPLICATIONS
- ELECTRO-ACOUSTICAL MEASUREMENTS

BRUSH ELECTRONICS

ELECTRICAL MEASUREMENTS

with Brush Oscillographs

These rugged instruments will operate continuously — with minimum attention.



Brush Instruments can measure the roughness of a hair . . . or the strain in a mammoth power shovel. When used with a Brush oscillograph, these measurements are put down in writing *instantly*. Brush oscillographs provide visible and indisputable proof that is permanent.

Among the many different types of measurements that may be recorded are, for example, electrical transients in motor starting circuits, relay sequence and timing, the performance of servo mechanisms, and testing saturable core reactors.

The design of these sensitive instruments provides a high degree of accuracy. Brush engineering and quality control in manufacture have made them physically rugged. You can depend on their operation

Brush pioneered Magnetic Direct-Writing Pen motors as well as the recording systems presented in this section. During the past decade, these instruments have helped thousands to improve their own products Brush Instruments may also be able to help you.

Perhaps you can make your own selection from the illustrations and descriptions of each instrument. If not, please phone, write or use one of the handy forms in the back of this booklet. We'll be glad to advise you without charge or obligation.

MODELS BL-902 AND BL-902A

BRUSH MAGNETIC PENMOTORS

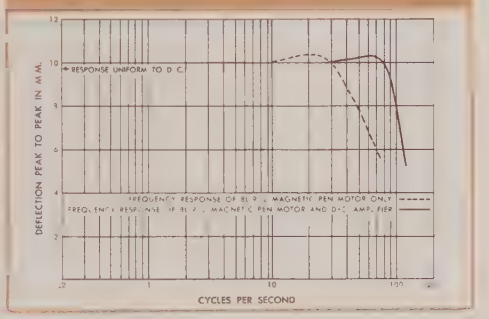
Model BL-902: for use where only one Penmotor is required.
Model BL-902A: for use where two or more are used . . . to record two or more measurements simultaneously.

Here is the accurate, dependable "hand" that records measurements instantly. One or more of these Penmotors is incorporated in every Brush Direct-Writing Oscillograph. Their high stability and linear phase shift permit accurate reproduction of both transient phenomena and steady state signals. These instruments find many uses in industrial and research measurements, as well as in electrocardiography, geophysical and seismic recording.

Each Penmotor is supplied with a direct-inking pen. In addition, if desired, an electric stylus for writing on electrically-sensitized paper is available. The electric stylus is recommended for use in high altitudes or where low temperatures and air pressures are encountered.

Brush Penmotors have a flat frequency response from D.C. through 30 cps. (See broken line on chart.) In combination with a Brush Amplifier, the frequency range can be extended through 100 cps. (See unbroken line on chart.)

Magnetic Penmotor—recording element in Brush Oscillographs.


DEFLECTION PEAK TO PEAK IN M.M.
RESPONSE UNIFORM TO D.C.
FREQUENCY RESPONSE OF BL-2 MAGNETIC PEN MOTOR ONLY
FREQUENCY RESPONSE OF BL-2 MAGNETIC PEN MOTOR AND D.C. AMPLIFIER
CYCLES PER SECOND

Permanent records . . . instantly.

MODEL BL-201 SINGLE CHANNEL
MODEL BL-202 DOUBLE CHANNEL

MAGNETIC DIRECT-INKING OSCILLOGRAPH

For high-speed recording of electrical signals instantaneously on chart paper.

The Brush Magnetic Direct-Inking Oscillographs employ either one Model BL-902 or two Brush Model BL-902A Penmotors mounted on a paper chart drive mechanism and protected by a metal cover finished in attractive black crackle. A hinged door in the cover gives quick access to inkwells, pen and chart paper for notations. Easy reloading of chart paper is provided.

Instantaneous electrical phenomena in the frequency range of D.C. to 30 cps can be faithfully recorded. Used with any of the Brush equalized amplifiers, this frequency range can be extended to 100 cps.

Ink records are furnished on curvilinear chart paper $2^{3}s''$ wide with the Model BL-201 Single Channel Oscillograph, and $3^{15}\!/_{16}''$ wide chart paper on the Double Channel, Model BL-202 Oscillograph. A synchronous 110 volt, 60 cps chart drive motor provides chart speeds of 5, 25 and 125 mm per second, easily controlled by an accessible speed shift lever. Portability is enhanced by a carrying strap.

Power Supply BL-944 (shown above, at left) is used with electric stylus.

MODEL BL-221 SINGLE CHANNEL
MODEL BL-222 DOUBLE CHANNEL

COMBINATION MAGNETIC OSCILLOGRAPHS

. . . with both electric stylus and ink pen.

These models are identical to the BL-201 and BL-202 except fo circuit changes that permit the use of either a standard inking pe or electric stylus. The electric stylus is recommended for use in hig altitudes, or where low temperatures and light air pressures ar encountered.

A BL-944 Power Supply is furnished with both models. It provide a choice of voltages suitable for high or low writing intensities. Th Oscillograph power switch disconnects the power supply when i "OFF" position, providing a safety feature when handling electric stylus

MODEL BL-206 INK-WRITING
MODEL BL-208 COMBINATION

SIX CHANNEL MAGNETIC OSCILLOGRAPHS

For recording numerous signals as in vibration analysis, wind tunnel studies, etc.

Up to six different measurements recorded simultaneously. Both models have six Magnetic Penmotors mounted in line, as illustrated, which record on a paper roll 12″ wide. Chart paper may be rerolled if desired. The BL-206 is supplied for ink writing only. The BL-208 is equipped for either inkwriting or recording with electric stylus. Both models will record voltages from D.C. through 100 cps (when used with Brush Amplifiers).

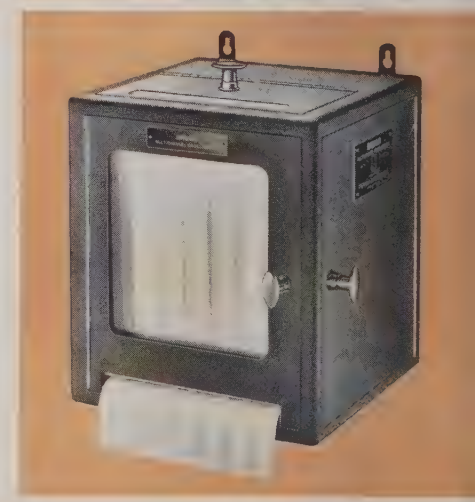
Junction Box is also furnished. This has a control switch for the Chart Drive motor, as well as connectors for either input amplifiers or for the circuits to be recorded. On Model BL-208, the Junction Box also includes a Power Supply for the electric styli, as well as individual stylus controls of high and low writing intensity.

The Oscillograph is regularly supplied with a 30 RPM synchronous 110 V 60 cps motor providing chart speeds of 125 mm/sec. and 25 mm/sec. The unit can be ordered with a choice of one high chart speed and one corresponding low chart speed as shown below.

High Speed	Low Speed	
	Gear Shift Ratio 5:1	Gear Shift Ratio 10:1
125 mm/sec.	25 mm/sec.	12½ mm/sec.
100 mm/sec.	20 mm/sec.	10 mm/sec.
50 mm/sec.	10 mm/sec.	5 mm/sec.
25 mm/sec.	5 mm/sec.	2½ mm/sec.

6 RPM motor—divide all figures above by 5
3 RPM motor—divide all figures above by 10
Chart drive motors available 30, 6 and 3 RPM.

Multi-channel recording . . . simultaneous . . permanent.



MODEL BL-226

PORTABLE SIX CHANNEL, DIRECT-INKING, MAGNETIC OSCILLOGRAPH

The Model BL-226 Six Channel Oscillograph is designed for multi-channel recording where the need for a lightweight, compact and portable instrument is of prime importance. The oscillograph can be operated on a deck or table and readily moved from place to place.

The Model BL-226 Six Channel Oscillograph employs six Model BL-902A Penmotors mounted in line, ink recording on a 12″ wide chart paper. Chart speeds of 5, 25, and 125 mm per second are available. Controls are furnished to start or stop the chart drive system or select the desired chart speeds. On special order, a remote control panel can be furnished to permit operation from a distant location. To further facilitate operation, connections are also available on the remote panel and oscillograph for use of a foot switch to permit starting or stopping of the Chart Drive system.

A Junction Box with 25 feet of cable is supplied with the oscillograph which provides all the necessary outlets for the connection of six Brush Amplifiers.

The Oscillograph is mounted in an aluminum case with a stainless steel top cover, to permit access to pens and ink wells. A window in the case allows the operator to view the chart at all times.

Portable six channel oscillograph.

ACCESSORIES FOR BRUSH OSCILLOGRAPHS

Records event information.

MODEL BL-401 INK WRITING
MODEL BL-421 ELECTRIC WRITING

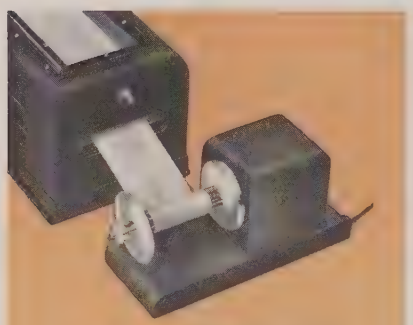
EVENT MARKER

Useful on Oscillograph where an accurate time base is required, or where it is necessary to synchronize or correlate events, mark shaft revolutions, etc. Makes small traverse mark on or near the margin of the chart paper. Event markers are usually supplied with 6 volt D.C. solenoid coil and are also available with 12, 24 or 60 volt D.C. coils. Choice of either right or left hand mountings. Other models supplied for six channel Oscillographs.

MODEL BL-931

KIT for SLOW CHART DRIVE

Provides three chart speeds of 50, 250 and 1250 mm/hour in addition to standard speeds of 5, 25 and 125 mm/sec. May be installed on any standard single or double channel Oscillograph by the user, or at the factory. Usually supplied with 10 RPM motor but are also available with 1, 5 and 30 RPM motors, providing corresponding chart speeds.



Convenient means for rerolling chart paper.

MODEL BL-933

CHART TAKE-UP DRIVE

Here is a convenient means of reeling recorded single or double chart paper into a form which is readily stored. It is especially useful when it is necessary to keep a record of measurements taken over a long period of time.

The motor drive system is sufficiently flexible to permit operation at all Oscillograph chart speeds. The take-up reel is designed with a snap on outer flange and a spring type hub which facilitates the removal of chart paper. The Chart Take-Up Drive is a complete unit and may be placed in any convenient location.

CHART PAPERS for BRUSH OSCILLOGRAPHS

Brush chart papers are radially ruled in millimeters. Each recording channel on multigraph channel chart papers is 40 mm wide. The single channel paper recording width is 50 mm. You may order conveniently from the following chart:

Oscillograph Model No.	Chart Papers
BL-201 and BL-221	Single Channel Oscillographs, use BL-908 Single Channel Chart Paper (175 ft. rolls); BL-923 Single Channel Chart Paper (350 ft. rolls).
BL-221	Single Channel Combination Oscillograph, you may also use BL-938 Single Channel Electric Stylus Chart Paper (100 ft. rolls).
BL-202 and BL-222	Double Channel Oscillographs, use BL-909 Double Channel Chart Paper (175 ft. rolls); BL-924 Double Channel Chart Paper (350 ft. rolls).
BL-222	Double Channel Combination Oscillograph, you may also use BL-939 Double Channel Electric Stylus Chart Paper (100 ft. rolls).
BL-206 and BL-208	Six Channel Oscillographs, use BL-907 Six Channel Chart Paper (850 ft. rolls).
BL-208	Six Channel Combination Oscillograph, you may also use BL-937 Six Channel Electric Stylus Chart Paper (500 ft. rolls).
BL-226	Portable Six Channel Direct-Inking Oscillograph, use BL-941 Six Channel Chart Paper (425 ft. rolls).

MODEL BL-502

TRANSIENT RECORDER

For studying transient phenomena of .2 seconds or less.

Electrical transients or any other short-duration phenomena capable of being converted into electrical impulses may be recorded on the Transient Recorder and reproduced automatically on an oscilloscope. The Model BL-502 Transient Recorder is used with an oscilloscope (not furnished) for viewing transient phenomena, after it has first been recorded on the steel tape of the BL-502. Reproduction repeats continuously for visual analysis by a cathode ray oscilloscope. Signals may be photographed in entirety or expanded on the oscilloscope screen to show detail. Any oscilloscope with low-frequency sweep may be used. These results are accomplished by magnetically recording on a rapidly moving steel tape a frequency modulated high-frequency carrier. Reset button clears tape and prepares it for a new record.

This instrument is especially valuable for recording momentary transients such as those produced by vibrations, explosion waves, light flashes, welding cycles and similar occurrences.

Records transients on tape. Replays on Oscilloscope.

MODEL BL-905

SINGLE CHANNEL AC AMPLIFIER

A four-stage amplifier, designed especially for use with the Brush Magnetic Penmotor.

This high gain AC amplifier is designed for use with the Brush Magnetic Oscillograph to maintain relatively flat frequency response from ½ to 100 cps. A meter and a minimum of controls facilitate calibration of the amplifier and oscillograph. Attenuation is in multiples of ten for easy computation.

Provision in the amplifier circuit is made for high frequency compensation, such that the overall frequency response of the penmotors combined with the amplifier may be considerably extended. Low impedance output circuit provides correct damping for Penmotor. Amplifier is designed to prevent severe overloads from damaging Penmotor coil.

High gain AC Amplifier.

MODEL BL-928 PORTABLE
MODEL BL-968 FOR RACK MOUNTING

DUAL CHANNEL D-C AMPLIFIERS

Developed primarily for use with any dual channel Brush Magnetic Oscillograph where high gain is not essential. Recommended (for use with Oscillograph) to study the characteristics of storage batteries, D.C. generators and motors. Also to make electrolysis surveys and check photocell outputs, or for electrocardiograph or electroencephalograph work when used with high gain preamplifier.

Each channel in these instruments will simultaneously amplify electric phenomena with amplitudes of 50 millivolts or more. Has a frequency range of 0 through 100 cps. Voltage gain approximately 25 times.

Control panel has "factor of 10" attenuators, gain controls, and pen-positioning bias controls for both amplifiers. An accurate, standard cell provides the source for D.C. calibration.

PORTABLE

RACK MOUNTING

Two-channel amplifier for use with Brush Dual Channel Oscillograph.

High Gain D-C Amplifier.

MODEL BL-932 PORTABLE
MODEL BL-962 FOR RACK MOUNTING

HIGH GAIN D-C AMPLIFIER

Direct-Coupled Amplifier for use with Brush Oscillographs.

The Single Channel D-C Amplifiers consist of five direct-coupled stages of amplification, and an electronically regulated power supply, designed to permit recording of voltages down to 1 millivolt when used with the Brush Direct Writing Oscillograph. The wave form of electrical phenomena in the frequency range of D.C. to 100 cps is faithfully charted and ready for immediate use. Studies of static or dynamic conditions such as strain, displacements, pressures, light intensities, temperatures, D.C. and A.C. voltages or currents, and many others are simplified by the use of the Brush Direct Writing Oscillograph with the Model BL-932 or BL-962 D-C Amplifiers.

The Model BL-932 Amplifier is designed for portability, ease of operation, and is furnished in a black crackle finished metal cover with a convenient carrying handle.

The Model BL-962 Amplifier is available for engineers who desire permanently mounted instrumentation. It makes use of the same circuit as the BL-932 Amplifier, but is designed for mounting in a standard 19″ rack.

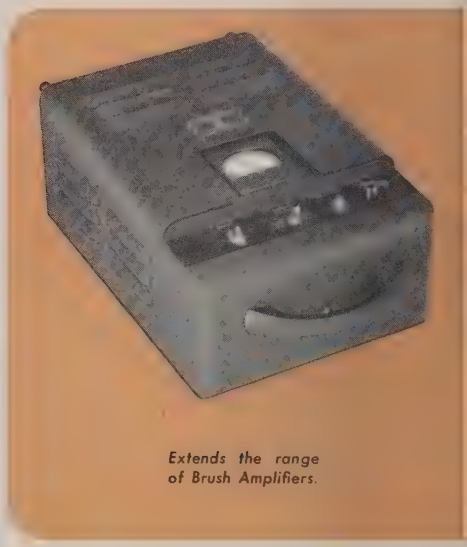
MODEL BL-954

HIGH GAIN PREAMPLIFIER

For voltages as low as 5 microvolts, when used with a Brush Amplifier and Oscillograph.

You can record voltages as low as five microvolts by adding this Brush Preamplifier to an amplifier-oscillograph combination. It permits such sensitive measurements as electrical responses from a brain, heart or nerve! Its flexibility and wide frequency range (from .2 through 400 cps) make it useful in both industrial and medical fields. Can be used with a Cathode Ray Oscilloscope or Light Ray Galvanometer if used with a stage of power amplification. Maximum gain of this Preamplifier is 200,000.

To reduce interference and insure stable operation, the BL-954 is battery operated. Noise level is equal to an equivalent two microvolt input.



Extends the range of Brush Amplifiers.

PHYSICAL MEASUREMENTS

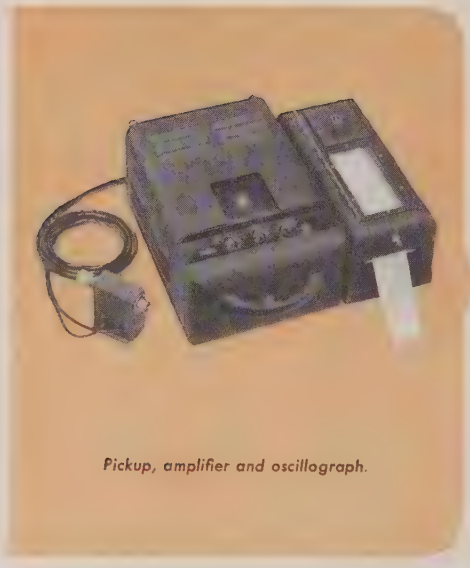
Every year, industry is challenged to mass produce parts and products that call for closer tolerances and higher degrees of uniformity. No wonder that industrial laboratories are "moving out" into the production lines to study characteristics of the machines. Vibrations, torques, strains and many other factors can affect product uniformity, costs and profits.

In this section you will find the special Brush Instruments used for these purposes. Now permanent records of measurements can be easily made of either static or dynamic characteristics of acceleration, displacement, force, torque, position, pressure, strain, tension and vibration. With these complete records, your problem can be easily analyzed and solved.

MODEL BL-309 AMPLIFIER

DISPLACEMENT RECORDER

Records displacement.



Pickup, amplifier and oscillograph.

Three instruments, the Model BL-306 Displacement Pickup, Model BL-309 Displacement Amplifier, and Model BL-201 Single Channel Oscillograph, are combined to give a complete displacement analyzing system. This system is capable of recording minute displacements as low as .000010″ and as high as .015″. The Model BL-306 is an inductive-type displacement sensitive pickup. The displacement amplifier energizes the pickup and amplifies the output. The displacement is then recorded on the Model BL-201 Single Channel Magnetic Oscillograph to produce immediate records of absolute values.

The direct recording displacement gage is useful for many industrial and research problems, such as the measurement of pressures, forces, vibrations and other phenomena which involve a displacement or a change in dimensions. The equipment is particularly well suited to checking eccentricity of shafts or the contour of cams or other irregularly shaped sections by comparison with a master. The versatility of this instrument makes the number of its uses almost endless.

Besides recording displacement, the three D-C output stages of the Displacement Amplifier may be used as a low gain amplifier for recording many electrical signals. An input jack, gain and centering controls are provided.

MODEL BL-312

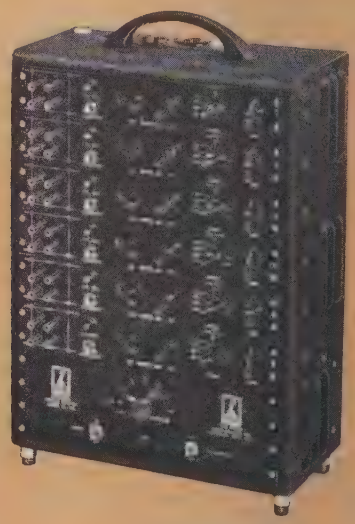
UNIVERSAL* BRIDGE SWITCH

The BL-312 Universal Bridge Switch, in combination with the BL-320 Universal Amplifier and a Double-Channel Direct-Writing Oscillograph does the work of six BL-320's, with a minimum investment in equipment, where simultaneous readings are not necessary.

The Universal Bridge Switch enables you to make consecutive recordings of strains from as many as six different locations. Each channel provides controls for balancing and calibrating a four-arm resistance sensitive bridge.

A master switch enables you to scan all or any of the six channels in use. As the strain measurement is being recorded on one channel of the oscillograph, the bridge switch generates a coding signal, recorded simultaneously on the adjacent channel, identifying both the measuring channel and attenuator setting being used.

*Trademark Reg.



Provides six bridge circuits.

MODEL BL-320 PORTABLE
MODEL BL-360 FOR RACK MOUNTING

UNIVERSAL AMPLIFIER

This high-gain carrier-type amplifier in combination with the oscillograph and proper gage or pickup, is used to measure and record pressures, temperatures, accelerations, strains, vibrations and other physical phenomena.

PORTABLE

RACK MOUNTING

High gain carrier-type amplifiers.

The Model BL-320 or BL-360 Universal Amplifier, when used with the Brush Magnetic Direct Writing Oscillograph, provides a complete package unit for the measurement of strain or other phenomenon where a resistance sensitive pickup is employed. It can be easily operated, producing records which are immediately available and readily interpreted. This equipment combination records either static or dynamic strains up to 100 cps, and direction as well as magnitude of the measured strain can be read from the chart. This permits easy static calibration of the system.

Connections are brought out for a four arm bridge, and one to four active gages may be used. The Model BL-360 is equipped with input and output connections on back of chassis as well as on the front panel. When less than four active gages are used, dummy gages or precision resistors may be substituted for the missing gages to complete the bridge network. One of the dummy gages may be used for temperature compensation when one active gage is employed. Provision is made for connecting your choice of calibrating resistors in the bridge circuit. The calibrating resistor normally supplied is intended for use with the SR-4 120 ohm strain gage. Overall gain can then be adjusted so that strain can be read directly in microinches per inch from chart deflections.

Although primarily intended for use with the SR-4 120 ohm strain gage, it is possible to use any gage type with ohmic resistance of 50 to 1000 ohms.

Besides recording physical phenomena, the three D-C output stages of the Universal Amplifier may be used as a low gain amplifier for recording many electrical signals. An input jack, gain and centering controls are provided.

BRUSH CRYSTAL VIBRATION PICKUPS

Industry has found many uses for Brush Pickups. Among them are: production counting of small parts, locating noise or vibration in machinery and finished products, finding leaks in underground water lines, dynamic balancing of rotating parts, as well as production testing of many kinds.

These pickups must be used with an amplifier to boost the input signal. Brush Pickups can be used with a volt-meter, electronic relay, or oscilloscope. When used with a Brush oscillograph, permanent records are instantly provided.

All Brush Vibration Pickups have a Brush Piezo-Electrical Crystal . . . a dependable and highly sensitive element. This is one reason Brush Pickups are lightweight, compact and rugged.

In addition to the vibration pickups shown here, a complete vibration analysis system is described in the "Electro-Acoustical Measurements" Section of this brochure. This system is comprised of a Model BL-4304 Vibration Pickup, Model BL-1604 Integration Network, and Model 2105 Frequency Analyzer. A complete vibration spectrogram may be obtained for acceleration, velocity or displacement in the frequency range of 47 cps to 1500 cps.

MODEL BL-301. ACCELERATION TYPE

VIBRATION PICKUP

For frequencies through 2500 cps. It measures, in voltage output, the acceleration of vibration. Voltage output of this Pickup is proportioned to the *velocity* of vibration. By using a simple integrating circuit, you can make the voltage output of the Pickup proportioned to the *displacement* of vibrations.

MODEL DP-1. DISPLACEMENT TYPE

DISPLACEMENT PICKUP

For frequencies of one through 600 cps, ± 15%. Will reproduce frequencies through 7000 cps. Measures the extent or amplitude of vibrations.

MODEL DP-1-H. HEARTBEAT PICKUP

HEARTBEAT PICKUP

(Displacement type.) Used with matching amplifier, it is highly sensitive with a wide frequency range and supplements the stethoscope. Frequency characteristics are same as for Model DP-1. Amplifies sounds from chest as well as heart. Ideal for lectures and classrooms. Strap loops permit fastening to patient for continuous records. Rubber diaphragm easily removed for sterilizing.

SURFACE MEASUREMENTS

The surface finish of many types of products is becoming increasingly important. Surface finish limits are being specified on more and more parts to keep costs down and improve performance. Manufacturers are not willing to pay suppliers for surface finishing where it is not required. Furthermore, parts suppliers may be able to submit more attractive bids by eliminating *over*-finishing.

As a matter of fact, over-finishing the surfaces of some types of products and parts actually lowers their use-value and quality. Other products must have surfaces that are extremely well finished, and highly uniform.

How can a manufacturer successfully specify the degree of surface finish on parts? This problem is still greater when a manufacturer has several subcontractors, all of whom are supplying the same parts. The practical answer is for the manufacturer to require use of the same surface measuring system by all suppliers.

In this section are Brush Instruments for surface measuring and analysis. You (or your suppliers) can easily select the equipment to meet your particular requirements, or we shall be glad to advise you. Just use one of the convenient reply forms in the back of this booklet.

A practical shop instrument designed for accurate measurement of surface finish.

MODEL BL-110

SURFINDICATOR*

A new versatile gage for surface roughness measurement.

Here is a surface measuring instrument designed especially for inspection and production use. Maximum usefulness has been assured since the SURFINDICATOR is portable, inexpensive, reliable, easy to operate and adaptable to a wide variety of work.

This rugged simple-to-operate instrument can be used by shop personnel after only a few minutes instruction. The compactness and light weight of the SURFINDICATOR permit measurements anywhere in the plant, with the work in the production machine if desired. The surface roughness range measured extends from 1 to 1000 microinches arithmetic average deviation from the mean surface.

The variable cut-off switch permits the separation of waviness and roughness characteristics of surfaces by filtering out wave lengths exceeding .003″, .010″, or .030″. This feature is of great importance in many applications; such as bearing surfaces and highly stressed parts.

The Caliblock Precision Reference Specimens provide a simple and absolute calibration of the SURFINDICATOR. The possibility of measurement errors with different operators and between different instruments is thus eliminated. These specimens have a geometric surface profile with accuracy limits as low as one millionth of an inch, and do not vary in roughness throughout their area as do surface specimens produced by ordinary machine processes.

The Pickup head is provided with a handle for hand tracing and is designed to be adaptable to a wide variety of surface shapes. For very small or irregular pieces, which may not be conveniently examined by the hand tracer, the pickup may be adapted to motor traces, extension handles, or special jigs.

A full line of accessories to the SURFINDICATOR is contemplated and will be announced as they become available.

The SURFINDICATOR was developed by General Motors Corporation and is manufactured by the Brush Electronics Company under license.

MODEL BL-122

FAXFILM* SURFACE COMPARATOR

A rapid, non-destructive process for visual examination and comparison of surfaces.

Ideal for quality control on production runs. A master replica of the desired surface is always available for accurate comparison with current production.

With the Faxfilm Comparator you can, for example, determine the machining characteristics of metals. During wear or life tests, you can record the *progress* of wear. After the tests are completed, you can compare surface conditions of the specimens as they were at each stage of the test. Comparisons are accurate since they are made at 30 times actual size.

You can use this instrument on woods, ceramics, fibrous materials, crystals or metals. It also supplies qualitative information such as: tear, porosity, chatter and uniformity of finish. Provides permanent replicas that are easy to file. Replicas can also be used as negatives to make photographic prints.

*Trademark Reg.

A method for examining actual replicas of surfaces at 30 times size.

RESISTANCE—WELDING MEASUREMENTS

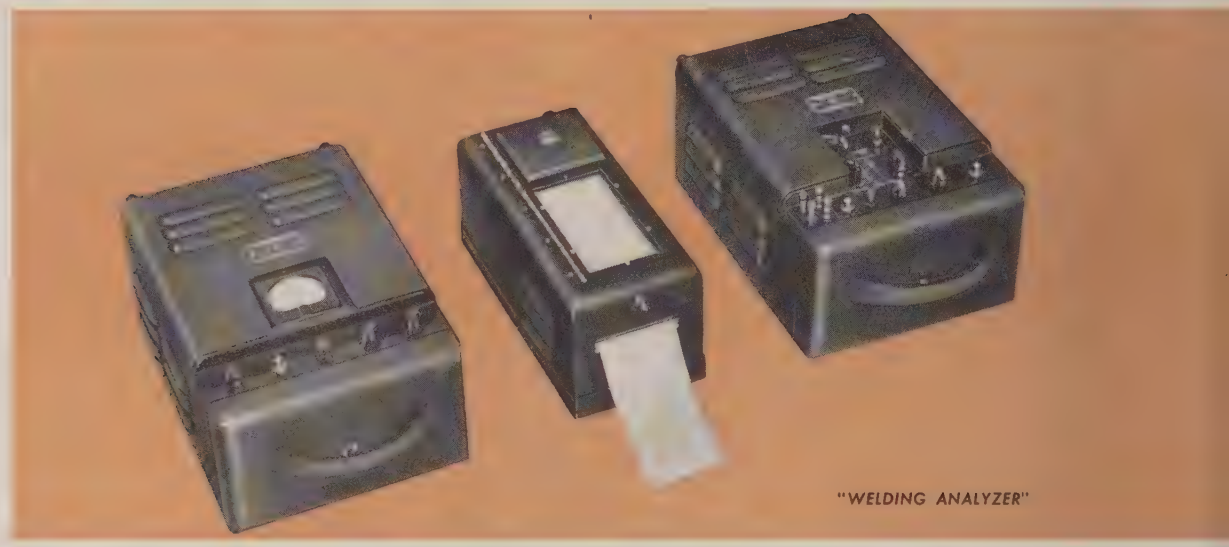
Manufacturers requiring metal fabrication processes, as with all industries, are continually striving for methods to increase production, decrease production costs and insure consistently higher quality of products. The welding expert, through his knowledge of welding techniques and welding machines, is demonstrating to manufacturers that welding cannot only satisfy the above requirements, but can insure a safer and stronger product.

To achieve greater knowledge of the welding machines, the welding engineer has sought out accurate and reliable instrumentation. Welding engineers have found Brush Instruments of great value for proving the operation of Resistance Welding Machines by instantaneous recording of weld current or primary current amplitude and timing. Electrode force or welding pressure is then correlated on the Brush Model BL-202 Direct-Writing, Magnetic Oscillograph.

The Brush Model BL-905 AC Amplifier or BL-932 D-C Amplifier is used in conjunction with the Model BL-202 Magnetic Oscillograph for showing the 60 cps weld current or primary current amplitude and timing sequence experienced in the single phase resistance welding machines. The combination clearly indicates the 60 cps current variations, giving an accurate method of timing the weld period to less than ½ of a cycle of 60 cps frequency.

For measurement of electrode force, Brush offers its Model BL-320 Universal Amplifier for use with one channel of the Model BL-202 Magnetic Oscillograph referred to above. This combination will clearly indicate any sudden pressure variations from 0 to 100 cps. This accurate timing of variables speeds set-up time, lessens down-time of the welding machine, and shows consistency of welding machine operations.

To extend the usefulness of Brush Instruments to include measurements on three-phase resistance welding machines, Brush has recently announced the Model BL-213 Welding Analyzer described here.



MODEL BL-213

WELDING ANALYZER

Proves accurate timing and correlation of three-phase resistance welding variables.

The Model BL-213 Welding Analyzer consists of a modified BL-932 Direct-Coupled Amplifier, Model BL-320 Universal Amplifier, and a special BL-202 Direct-Writing Oscillograph. This instrument was designed to achieve more accurate timing of the D.C. or low frequency weld current and electrode force in the three-phase resistance welding machines—spot, projection and seam.

The Modified BL-932 D-C Amplifier when used with one channel of the special BL-202 Direct-Writing Oscillograph will record not only the D.C. or low frequency A.C. signals, but will record the 180 cps ripple superimposed on the weld current. Not only can more accurate timing be achieved, but any irregularities in the operation of the electronic tubes controlling the weld current can be observed in the recorded 180 cps ripple signal.

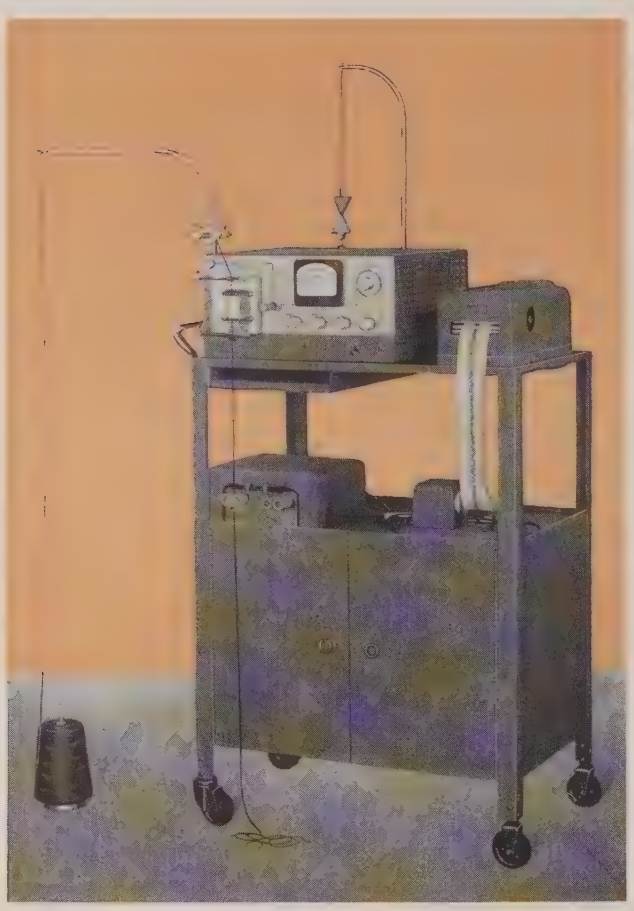
The Brush Model BL-320 is used in conjunction with the other channel of the special BL-202 Direct-Writing Oscillograph to correlate electrode force with the weld current. The immediate recording correlating weld current and electrode force affords a quick and easy method to "set-up" the controls on the resistance welding machine, and also allows for immediate check of the welding machine "set-up" during production operation.

TEXTILE MEASUREMENTS

The textile industry has made continued technological improvements since the basic principles of spinning and weaving were first developed several thousand years ago. Watching the whirring spindles on today's modern spinning frames, it is difficult to realize that less than 300 years ago, the spinning wheel had a prominent role in every home.

Since that time, the design of textile machinery has continually improved, and during this same period textile measuring equipment has advanced from visual examination methods used in the past to the modern electronic methods used today. The Brush Electronics Company's initial contribution to the field of electronic textile measurement is the Uniformity Analyzer which measures the non-uniformity of yarn in its several stages of manufacture.

The Brush Uniformity Analyzer is now being used by many progressive textile mills and has saved these organizations thousands of dollars in production costs and played a major role in helping them produce top quality yarns. The Brush Uniformity Analyzer may be used to test new stock for desired qualities, or to trace defects to their sources by studying the chart record and applying the information to the processing cycle. Sources of non-uniformity can be pinpointed by analyzing material before and after a particular process. These uses, plus many others, enable owners of Uniformity Analyzers to keep their machinery at optimum settings and thereby insure products of highest quality and at lowest cost.



Measures and records irregularities in weight per unit length of yarn, roving or sliver.

MODEL BL-314A

UNIFORMITY ANALYZER*

The BL-314A Brush Uniformity Analyzer is an electronic measuring device which materially reduces the time required to determine irregularities in weight per unit length of yarn, roving or sliver. As the material travels through the electronic measuring head, a meter indicates either the average count of yarn, or the average percent of non-uniformity of yarn, roving or sliver. The oscillograph simultaneously writes a permanent graphic record on chart paper of the weight of material in a unit length, which may be evaluated to give a numerical value to the "non-uniformity" of this material.

The Uniformity Analyzer is calibrated for cotton but with only minor changes can be adapted to wool, nylon, rayon and other synthetic materials.

The yarn is touched only by the guide eyelets and feed rolls and is not compressed or distorted in any way. With the use of rewinding equipment, the material may be subjected to further testing or put back into production.

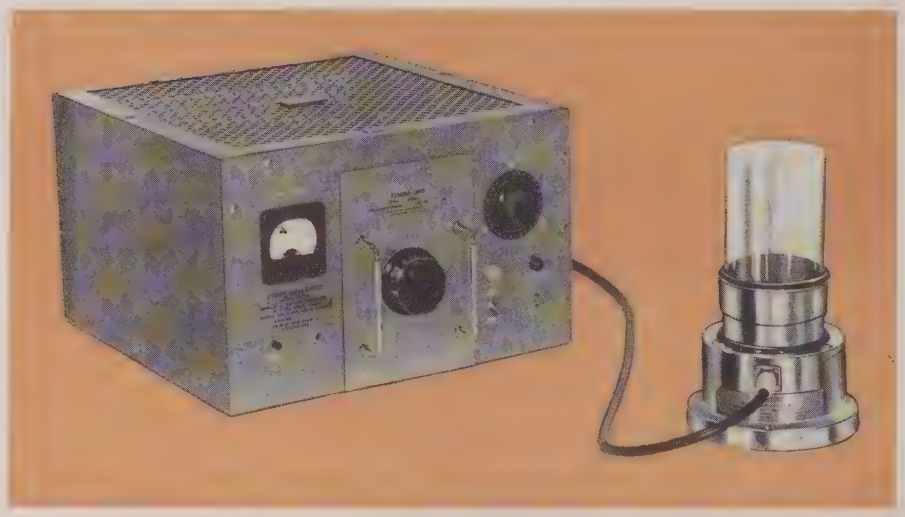
*Trademark Reg.

ULTRASONIC ENERGY APPLICATIONS

Ultrasonic energy, sound vibrations at frequencies above the range of human hearing, has been known for over fifty years. Until recently, however, it has been merely a laboratory curiosity because of the limited size of available equipment. As the result of a Brush research with Ceramic "A" (barium titanate), a ceramic material which exhibits piezo-electric properties, Brush was able to foresee the possibility of using this ceramic as a high power ultrasonic transducer.

At the present state of the art, each application of ultrasonics represents a special research and development program in itself. For this purpose, Brush has made available a line of standard HY-PERSONIC Equipment. This equipment has been designed primarily as a research tool to investigate various applications of ultrasonics.

Brush engineers are experienced in the design and construction of special ultrasonic equipment. When your application reaches the pilot plant level we will be pleased to consider the design of the proper equipment to meet your specific needs.



BU-204 Generator

BU-305A Transducer

HYPERSONIC* EQUIPMENT

The Model BU-204 Hypersonic Generator and the Model BU-305A Hypersonic Transducer constitutes an efficient working unit for convenient use in research laboratories. The equipment generates and focuses ultrasonic energy in a small area thereby attaining very high acoustic intensities. It permits extensive research in the applications of ultrasonics to the chemical, biological and industrial fields.

Covering the frequency range of 400 to 1000 KC, the Hypersonic Equipment allows treatment at intensities usually provided in only large apparatus. It will operate continuously over prolonged periods.

The versatility and ease with which Hypersonic Equipment may be incorporated into experimental ultrasonic processing set-ups make it a valuable laboratory tool.

*Trademark Reg.

ELECTRO-ACOUSTICAL MEASUREMENTS

Electro-acoustical measurements are in general, more difficult and less precise than the electrical measurements to which most of us are accustomed. The human ear, with its wide sensitivity range of 150 db and its near logarithmic response, places unusual requirements on acoustic measuring devices. Further, sound energy cannot be neatly channeled in wires and wave guides. Ambient noise energy, reflected and refracted sound, all introduce problems. Users of acoustical equipment are acutely aware of these factors.

The Brush Electronics Company is the exclusive distributor throughout the United States and Canada for electro-acoustical instruments, manufactured by Bruel and Kjaer (Denmark), many of which are shown in this section. These instruments receive immediate acclaim when demonstrated to engineers who have had long experience in making acoustical measurements with individually constructed equipments. Dr. Bruel, an eminent acoustical engineer, has designed this equipment specifically to provide accuracy, convenience and flexibility in making these measurements. An inevitable saving in engineering time and costs is therefore realized.

The Bruel and Kjaer Deviation Test Bridge, Heterodyne Voltmeter and Megohmmeter listed in this section are particularly valuable in electronic testing for either laboratory use or production control.

Speeds Up Inspection.

MODEL BL-1502 AND BL-1507

DEVIATION TEST BRIDGES

For very rapid and accurate impedance measurements.

The Model BL-1502 and BL-1507 Deviation Test Bridges are extremely fast, direct-reading impedance measuring instruments. They are designed to accurately present a comparison with or a percentage deviation from an arbitrary external standard impedance. Wherever repetitive measurements of either the resistive, capacitive or inductive characteristic of a product or component are called for, these bridges cut measuring time to a minimum. Production testing is reduced to the simple operation of placing the item to be checked in a jig to obtain positive terminal contact, and instantly reading from the large illuminated meter scale the percent deviation from the desired value.

Each instrument contains two arms of a Wheatstone bridge internally, the two other bridge arms having their terminals external to hold the standard and the sample to be tested. The bridge is of the AC type and is fed from a built-in oscillator. The test signal frequencies are 1000 cps for the Model BL-1502 and 50,000 cps for Model BL-1507.

Maximum speed of operation is attained through the use of a meter with optimum damping and a large six-inch illuminated scale. Some of the outstanding features of the Deviation Test Bridges are:

(1) They make production tests at a rate of 4000 an hour.
(2) The large six-inch illuminated meter scale is very easily read.
(3) The range calibration and zero adjustment are readily performed by means of a built-in standard.
(4) The adjustment of controls is simple and need not be made but once for a series of comparisons against a single standard.
(5) A very high stability makes it unnecessary to recalibrate more than once a day.
(6) The meter is safeguarded against overload.
(7) The meter and instrument accuracy exceed .1% at zero point center scale for comparison readings and 5% of full scale when determining tolerances with respect to a standard.

MODEL BL-2423
MODEL BL-3423

MEGOHMMETER HIGH VOLTAGE ACCESSORY

For measuring extremely high resistances, exceedingly small currents, and D.C. voltages.

The Model BL-2423 Megohmmeter is a vacuum tube voltmeter with a very high input impedance and a highly stabilized voltage supply designed for the precise measurement of electrical resistance over a range from 100,000 ohms (10^5) to 10,000,000 megohms (10^{13}ohms). The instrument is also recommended for accurate measurements of D.C. voltages over a range of 0.01 volts to 2000 volts with a very high input impedance, and as a D.C. micro microammeter for current measurements from 10^{-11} amps to 10^{-4} amps with a voltage drop of only 1 volt for full scale deflection.

The Megohmmeter is useful for production control or laboratory study of the leakage resistance of condensers, cables, transformers, etc. As a voltmeter and micro microammeter, the instrument has many valuable applications in electrical, physical and radiation laboratories.

Two very stable measuring voltages, 10 volts and 100 volts are provided internally, the 10 volts measuring voltage being particularly suitable for measurements such as the insulation resistance of strain gauges and hearing aid capacitors. High input impedance of the Megohmmeter is attained through impedance conversion in the first stage by a dual triode operating as a cathode follower. Minimum grid-current due to ionization, photo-electric effect and secondary emission is accomplished by a low stabilized plate voltage.

Other notable characteristics are:

1. As Megohmmeter: Accuracy to within 3% for 6 lower ranges and 5% for highest range. As D.C. Voltmeter or micro microammeter, 2% for all higher ranges and 3% for lowest range.
2. Simplicity of operation assured by:
   a. Ease of switching ranges.
   b. Provision of key to rapidly charge condensers for measuring leakage resistance.
   c. Zero adjustment stable over all ranges.
   d. Megohm scales for both 100 volts and 500 volts.
   e. Facility for using external test voltage up to 1000 volts as provided in High Voltage Accessory Model BL-3423.

For fast, accurate production testing to 100 million megohms.

The Model BL-3423 Megohmmeter High Voltage Accessory, as shown above, uses thirty-four 30 Volt hearing-aid batteries and appropriate controls to supply a choice of either of three fixed test voltages or a variable voltage from zero to 1000 volts. An additional switch provides for the rapid testing of leakage resistance in capacitors by charging them quickly to the measuring voltage and after measurement quickly discharging them.

The High Voltage Accessory is a very valuable addition to the Megohmmeter Model BL-2423 for either production or laboratory testing of high insulation resistance.

Multipurpose Audio Frequency Analyzer.

MODEL BL-2105

FREQUENCY ANALYZER

For all kinds of Acoustical, Electro-acoustical and Vibration Measurements.

The Model BL-2105 Frequency Analyzer is a frequency-selective vacuum tube voltmeter for acoustical and electro-acoustical measurements. The Analyzer accurately performs the following functions:

MEASUREMENT OF VIBRATION AND NOISE SPECTRA:

Constant percentage bandwidth selectivity readily permits frequency analysis and gives a spectrogram presentation of frequencies from range 47 to 12,000 cps. The Model BL-4304 Vibration Pickup and Model BL-1604 Integration Network are used with the analyzer to provide a complete instrumentation for vibration measurements.

SOUND LEVEL METER:

The Analyzer provides an accurate measure of sound pressure or noise level conforming to ASA standards when used with a high quality microphone such as the Model BL-4111 Condenser Microphone.

VACUUM TUBE VOLTMETER FOR AUDIO VOLTAGES:

Full-scale measuring range extends from 100 microvolts to 1000 volts. A very low hum level enables the measurement of extremely small voltages down to several microvolts. Either a linear response may be chosen or a frequency selective response variable from 20 to 40 db octave selectivity.

MICROPHONE AMPLIFIER OR PREAMPLIFIER:

The Frequency Analyzer is designed for use with low power or high impedance voltage sources. A special power supply is provided internally for operating the Condenser Microphone Model BL-4111 or the Artificial Ear Model BL-4109. To permit operation as a preamplifier, output circuits are provided for connection to either the Model BL-2301 Level Recorder or other electronic equipment.

HARMONIC ANALYZER:

An analysis of harmonic distortion of pure tones may be performed using the Frequency and Distortion Measuring Bridge Model BL-1602 and the Analyzer combined. Harmonic content as low as 0.01% may be easily measured and read directly from the meter scale of the Analyzer.

Tunable 120 db attenuator

MODEL BL-1602

FREQUENCY AND DISTORTION MEASURING BRIDGE

For sharp attenuation of a single frequency

The Model BL-1602 Frequency and Distortion Measuring Bridge is a simply operated blocking network utilizing three parallel tuned T filters. It is tuneable through the range 47 to 12,000 cps. This bridge entirely blocks out a selected frequency in the audio range, as required in making a harmonic analysis.

In conjunction with the Frequency Analyzer Model BL-2105 harmonic components as small as 0.01% may be measured. Wherever an interferring frequency must be blocked out such as a hum voltage, the sharp 120 db attenuation provided by the instrument assures the complete elimination of the unwanted signal.

MODEL BL-4304 VIBRATION PICKUP

VIBRATION PICKUP

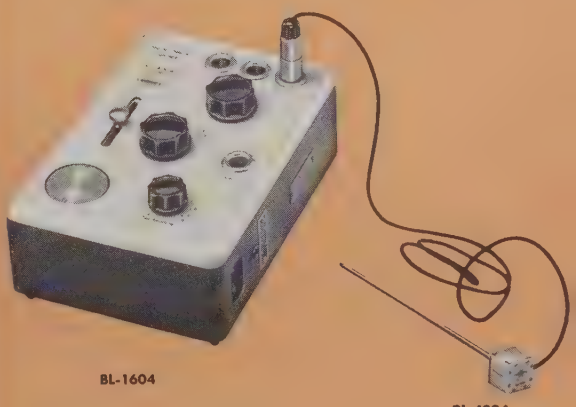
MODEL BL-1604 INTEGRATION NETWORK

INTEGRATION NETWORK

The Model BL-4304 Vibration Pickup is a lightweight 30 gram piezo-electric crystal device particularly suitable for vibration measurements on small, light engine parts, etc. The Model BL-1604 Integration Network consists of two RC filters and circuits to permit measurement of the amplitude of acceleration velocity, or displacement respectively of any vibrating unit. A driven tuning fork is incorporated to permit the calibration of the Vibration Pickup. Jacks and switchs are provided to permit the selection of either of three pickups for the reading or recording of data.

The Vibration Pickup and Integration Network are designed for use with the Model BL-2105 Frequency Analyzer. This combination gives the values of acceleration, velocity or displacement, readable directly from the meter scale. In addition, this instrumentation provides frequency spectrogram analysis of the vibration and can graphically record the data on the Model BL-2301 Level Recorder if desired.

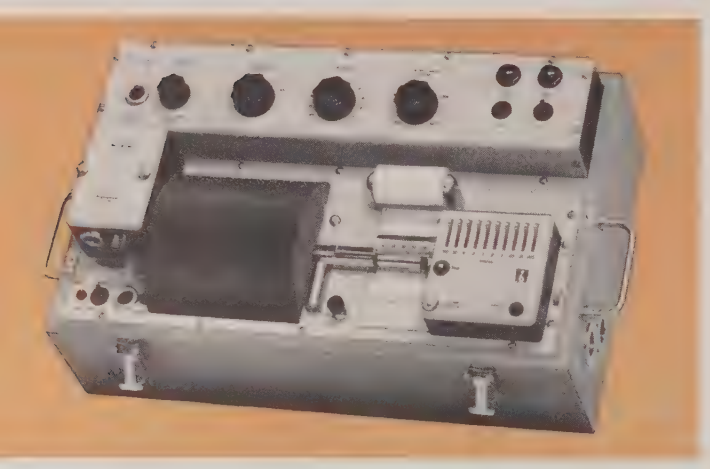
The Vibration Pickup utilizes the principle of a piezo-electric crystal clamped at three corners and loaded with a mass at the fourth corner to convert the physical motion to an electrical signal. The frequency range is 47 to 4000 cps, and the sensitivity for the pickup with cable connected to the BL-1604 Integration Network in the acceleration measuring position, is 10 mv/1000 cm sec^2.



BL-1604

BL-4304

For accurate vibration studies with Model BL-2105 Frequency Analyzer or other suitable analyzer.



High Speed Level Recorder.

MODEL BL-2301

HIGH SPEED LEVEL RECORDER

For rapid graphic rectilinear recording of measurements.

The Model BL-2301 High Speed Level Recorder is a servo-mechanism for accurately producing high speed graphic rectilinear recordings of signal level variations within the frequency range of 20 to 200,000 cps.

Its many features not only facilitate acoustical and electro-acoustical measurements, but also make it an extremely useful recorder for a wide field of applications.

The Level Recorder has proved most useful for the recording of reverberation decay curves, noise levels, electrical voltage levels, and particularly the frequency response curves of microphones, loudspeakers, filters, amplifiers, hearing aids, etc.

Recordings are made by either a sapphire stylus on wax coated paper or by an inking pen. Numerous recording ranges are provided by the input potentiometer, replaceable in any of the values of 10 db, 25 db, 50 db or 75 db full scale for a logarithmic recording characteristic. A linear potentiometer and a frequency weighted characteristic potentiometer also are available.

The principle of the Level Recorder's operation is that of using a null-balance type of stylus positioning made possible by a potentiometer-controlled moving coil stylus drive system.

Several of the important features of the Model BL-2301 Level Recorder are:

1. Choice of nine recording speeds ,in steps from 50 db to 1000 db per second.
2. Ten chart speeds, 0.003 mm to 100 mm per second.
3. Recording accuracy of better than 1%.
4. Zero reference level adjustable from 3 to 12 millivolts; a 10 millivolt standard signal is provided internally for calibration.

ACCESSORIES TO THE LEVEL RECORDER MODEL BL-2301

Model No.

BL-2340 Potentiometer in logarithmic ranges of 10, 25, 50, and 75 db. Linear Potentiometer with range from 10 to 110 mv.

BL-2341 Phon Potentiometer for noise registration from 35 to 110 phons.

BL-2350 Chart paper, perforated, lined, white for ink writing.

BL-2351 Chart paper, perforated, lined, wax coated.

BL-2352 Chart paper, perforated, lined, transparent wax coated paper to permit blueprinting.

BL-2355 Chart paper, similar to BL-2350 but preprinted for frequency response plotting with Oscillator Model BL-1012.

BL-2356 Chart paper, similar to BL-2351 but preprinted for frequency response plotting with Oscillator Model BL-1012.

BL-2360 Scratcher with eleven sapphires for drawing lines on unprinted wax coated chart paper.

BL-2370 Polar Diagram Recording attachment to permit plotting the directional characteristic of microphones, speakers, light sources, etc.

BL-2371 Polar Recording Turntable for rotating the objects to be measured. Includes flexible shaft for coupling to BL-2370.

BL-2371 Polar recording paper, wax coated.

BL-2372 Polar recording paper, transparent wax coated for blueprinting.

BL-4405 Rotating selector for successive connection to two different sources for measurement or for automatic noiseless switching of the B.F.O. Model BL-1012 for making reverberation measurements.

BL-4406 Universal Selector for use in conjunction with the Level Recorder and B.F.O. BL-1012 to automatically record on a closed loop of chart paper reverberation or energy decay curves displaced in small steps of frequency as in the BBC pulse gliding method.

BL-4610 Inverter using a 400 cps vibrator to permit the Level Recorder to make recordings of DC signals and low frequency AC.

Versatile Audio Signal Generator.

MODEL BL-1012

BEAT FREQUENCY OSCILLATOR

Complete signal source for electro-acoustical measurements.

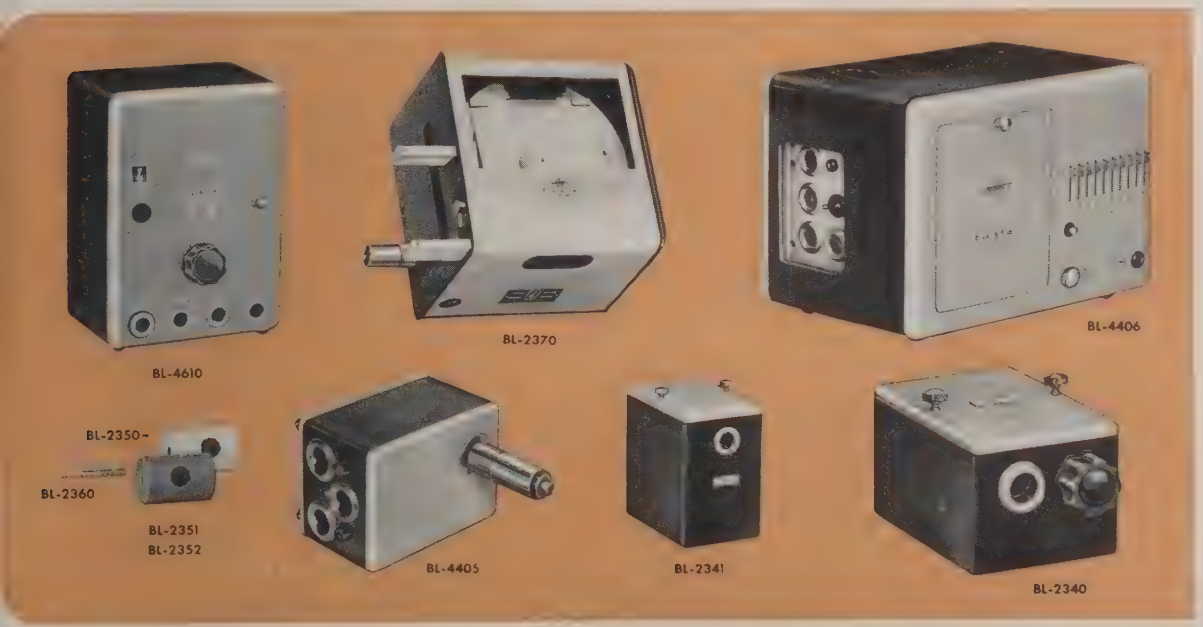
The Model BL-1012 Beat Frequency Oscillator is an extremely versatile Audio Signal Generator. In it there are numerous features designed to meet the unusual requirements of a signal source for electro-acoustical measurements.

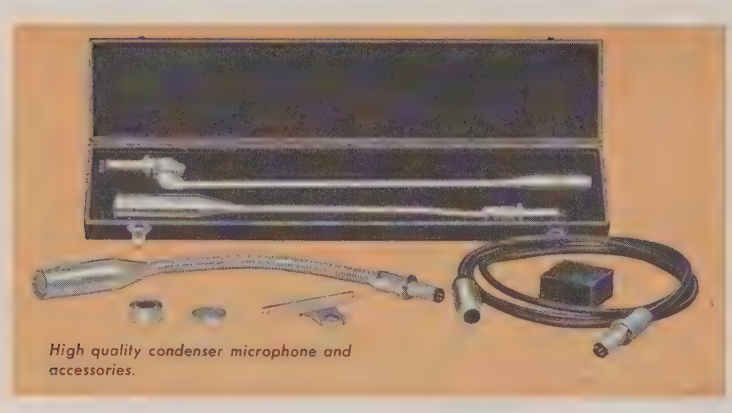
This Oscillator is especially useful for: measuring the frequency response characteristics of amplifiers, filters, transmission lines, loudspeakers and microphones; for electro-acoustical measurements; and for structural-acoustical research. There is provision for automatically sweeping through the frequency range of the oscillator by coupling through a flexible cable to the chart drive motor of the Level Recorder Model BL-2301. This combination of the Beat Frequency Oscillator and Model BL-2301 High Speed Level Recorder gives permanent and accurate recordings of frequency response, sound insulation properties, reverberation times, energy decay rates, etc.

For measurements such as those of reverberation times, the oscillator is equipped with a warble tone of variable modulation frequency and band width. In measurements as those of determining the response curve of microphones, hearing aids, etc. there is the need to maintain a constant sound pressure or constant voltage level. For this there is provided a variable compressor circuit.

The Model BL-1012 Beat Frequency Oscillator is well suited to a wide variety of measurements because of:

1. Frequency accuracy of 1% ± one cps.
2. An accurately calibrated attenuator variable in 10 db steps from 150 microvolts full scale to 15 volts.
3. A built-in precision vacuum tube voltmeter with a large illuminated mirror scale to indicate output voltage.
4. An incremental tuning adjustment and scale permitting very accurate frequency setting.





High quality condenser microphone and accessories.

MODEL BL-4111

CONDENSER MICROPHONE

Small, highly stabile microphone for precise sound measurements.

This small, rugged microphone is especially designed for making precision sound measurements. Exceptionally good calibration stability and high sensitivity permit accurate, dependable acoustical measurements to be made over a wide range of sound pressures. Applications of particular value are found in the exact measurement of noise levels such as those which are suspected of adversely affecting the health of personnel; measuring the frequency response of electro-acoustical devices; and as a standard of reference where an exactly calibrated microphone is required.

The special power supply to operate the microphone is incorporated in the Model BL-2105 Frequency Analyzer, Model BL-2109 Audio Frequency Spectrometer and Model BL-2601 Microphone Amplifier. Each microphone is supplied with its individual calibration curve over the frequency range 20 to 16,000 cps.

Features which make the Model BL-4111 Condenser Microphone exceptionally valuable for measurement applications are:

1. Linear frequency response within ± 2 db from 80 to 10,000 cps.
2. A sensitivity of about 2 millivolts per microbar, unaffected by humidity changes.
3. Temperature coefficient below ± 0.05 db per degree centigrade.
4. Built in cathode follower permits a long connecting cable to be used.
5. In selective sound measurements with the Model BL-2105 Analyzer, sound pressures down to 8 db above 2 x 10^{-4} microbar may be readily measured.
6. May be ordered with a matched Model BL-4113 Electrostatic Actuator to permit calibration with electrical voltages.

ACCESSORIES

FOR CONDENSER MICROPHONE BL-4111

BL-4112 Floor Stand with 3 meter cable to place the microphone 127 cm above floor.

BL-4113 Electrostatic Actuator. An individually adjusted measuring grating to permit recalibration of the Microphone BL-4111.

BL-4114 An Extension Cable 10 meters long.

BL-4115 Extension Rod 52 cm long with a toggle joint movable over 90°. This extension rod is desirable for the BL-2601 and necessary with the BL-2105.

BL-4116 Support for Rod BL-4115 required on BL-2105.

Acoustical Measurements Preamplifier.

MODEL BL-2601

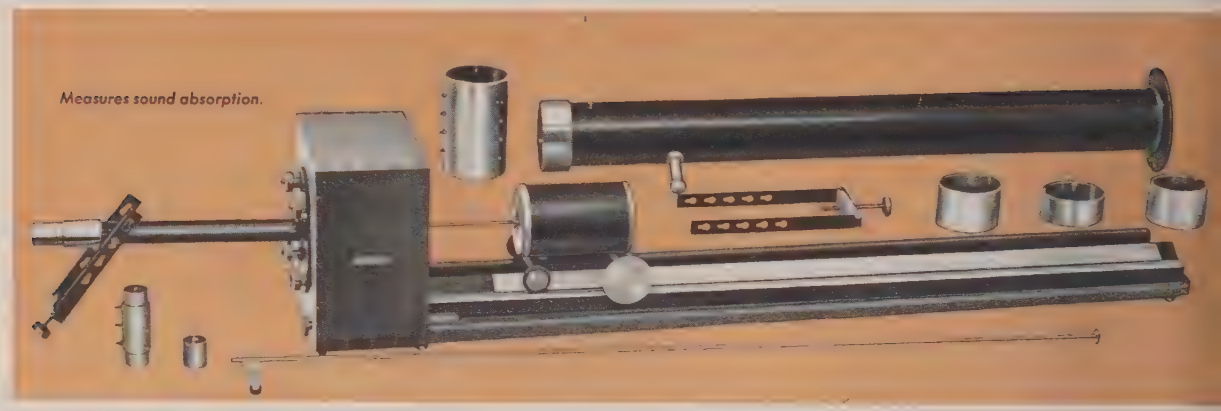
MICROPHONE AMPLIFIER

For distortionless, calibrated amplification of small audio voltages.

The Microphone Amplifier Model BL-2601 is a highly stabilized, hree-stage amplifier with an exceedingly low hum level. Designed articularly for use as a preamplifier in acoustical measurements, incorporates:

1. An accurately calibrated attenuator variable in both 10 db and 1 db steps over total range from —10 db to 80 db.
2. A switch to change the linear frequency response characteristic of the amplifier to either of the three internationally standardized antisonoric characteristics.
3. A built-in power supply and connection for Condenser Microphone Model BL-4111 plus a direct input connection for other signal sources.

As a linear amplifier, the frequency response is flat within ± 0.5 db om 20 to 20,000 cps, the range being restricted to these values to inimize thermal noise. Hum level is held to the extremely low alue of 2 microvolts referred to the input terminals.



MODEL BL-4002

STANDING WAVE APPARATUS

For easy and quick determination of acoustical absorption coefficients of materials.

The Model BL-4002 Standing Wave Apparatus utilizes the "Tube Method" of making an accurate and simple determination of the acoustical absorption coefficient and the specific acoustical impedance of small samples of sound absorbing materials. Sound from a loudspeaker is channeled down a tube to the material mounted at the end. The resulting standing wave created within the tube by the partially reflected sound will have a ratio of maxima to minima that is a direct function of the amount of sound absorbed by the material. This ratio is measured with a microphone, well insulated from air-borne noises and vibrations, and connected to a probe which extends through the center of the speaker and along the tube's axis.

An accurate signal source such as the BL-1012 Beat Frequency Oscillator is used to drive the speaker. The Model BL-2105 Frequency Analyzer is ideal as the microphone amplifier and indicating instrument. Its selectivity eliminates all extraneous signals and its meter scale, calibrated in percent, enables the coefficient of absorption to be read directly.

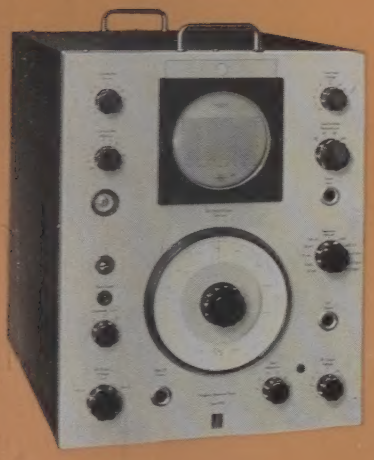
MODEL BL-4109

ARTIFICIAL EAR

For precision measurements and testing of earphones, hearing aids, or audiometers.

The Model BL-4109 Artificial Ear is a rugged, exceptionally stabile, calibrated condenser microphone physically mounted to permit accurate measuring of the sound output of earphones or hearing aids. It is particularly valuable when used as the accurate standardized pickup device for making rapid production tests with the Model BL-4707 or BL-4708 Automatic Frequency Response Tracer.

Standard couplers are provided—a 6 cc coupler for telephone and audiometer earphones and a 2 cc coupler for insert earphones. The specifications of these are in accordance with the ASA standard Z24.9. The special mirophone power supply for operating the Artificial Ear is incorporated in both the Model BL-2105 Frequency Analyzer and Model BL-2601 Microphone Amplifier.



For visual examination of frequency response curves.

MODELS BL-4707 AND BL-4708

AUTOMATIC FREQUENCY RESPONSE TRACER

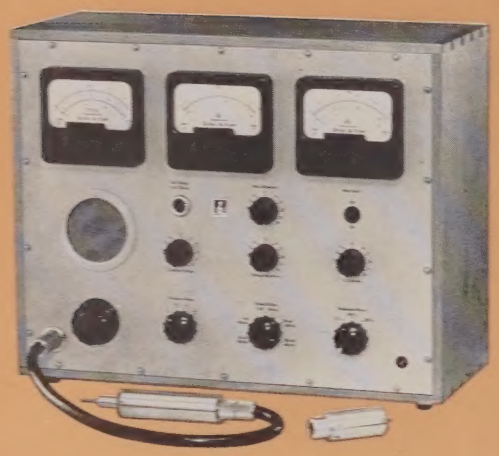
For rapid production checking of audio frequency response characteristics.

The Models BL-4707 and BL-4708 Frequency Response Tracers combine a motor driven audio oscillator and special oscilloscope in one unit to provide both the test signal source and visual indicator for automatically plotting frequency response curves. The operation is so simple and rapid that the use of the instrument greatly reduces the cost of production checking and adjusting of amplifiers, radios, filters, loudspeakers, microphones, telephones, hearing aids, etc.

The Model BL-4708 also provides a 1 megacycle 30% amplitude modulated signal for testing radios. On a shaketable, this permits concurrent rapid testing to be made for microphonics, resonances, short circuits, open circuits, intermittents, overall gain and frequency response. This one test provides "go" or "no go" checking.

The Frequency Response Tracers feature a cathode ray tube with a long persistance screen, a logarithmic vertical axis amplifier and a horizontal sweep synchronized with the motor driven beat frequency oscillator. The tube screen is calibrated with horizontal coordinates corresponding to the frequency scale of the oscillator and vertical coordinates in both decibels and millivolts. The oscillator section of the Model BL-4707 Response Tracer incorporates a variable compressor circuit that is very valuable in maintaining a constant sound pressure for testing microphones, hearing aids, etc. The Model BL-4708 has the audio modulated RF signal source in place of the compressor circuit.

The Artificial Ear Model BL-4109 is available as a standard coupler for all types of earphones.



Multipurpose High Frequency Voltmeter.

MODEL BL-2002

HETERODYNE VOLTMETER

High Frequency Voltmeter measures frequency, voltage and percent modulation.

The Model BL-2002 Heterodyne Voltmeter is an extremely high impedance frequency selective vacuum tube voltmeter for measurement of AC voltages down to several microvolts. This instrument is particularly designed to measure the amplitude of high frequency voltages and determine their frequency and percent amplitude modulation. A loudspeaker provides an audible signal check.

Valuable applications for the Heterodyne Voltmeter are found in radio laboratories for measurements on radio receivers, radar and television IF circuits; for the control of signal generators, and coaxial carrier frequency systems, etc. Its high sensitivity makes the instrument very suitable for measurements such as those of antenna voltages.

The instrument's operation is a basic super-heterodyne principle combining an untuned input circuit with an IF amplifier of high gain and selectivity. The frequency, input voltage, and amplitude modulation are indicated separately.

Important features to be noted are:

1. High input impedance of 5 megohms in parallel with 12 mmfd
2. The frequency range 20 kc to 27 Mc.
3. Voltage readings with full scale deflection from 10 microvolts to 10 volts in six ranges.
4. Voltage accuracy of ± .5 db.
5. An internal calibrating signal of 1 mv at 100 kc is provided.
6. A 40 db attenuator is provided as an accessory.

Warranty

Each new Brush Instrument is warranted for a period of one year from the date of sale against defective material or workmanship. This warranty is void if the instrument has been repaired by unauthorized persons or if it shows evidence of abuse or misuse. If this instrument fails during the warranty period, write to The Brush Development Company, 3405 Perkins Avenue, Cleveland 14, Ohio, Att: Customer Service Department, stating the date of purchase of the instrument and, if possible, the nature of the defect. Shipping instructions will be given and the instrument may be returned to us by express collect. If examination reveals defective workmanship or material, repair or replacement will be made without charge and the instrument returned to you prepaid.

All Brush instruments which are modernized or completely overhauled, will also carry the above instrument warranty. In the case of instruments which are repaired but not completely overhauled, this warranty shall extend only to the actual parts of the instrument repaired and not to the instrument in its entirety.

The time required for the repair of our industrial instruments is normally less than one week. However, if an instrument is being used in an application where it is of vital importance, loaner instruments can be provided to be used while your instruments are undergoing repair. No charge is made for loaner instruments other than the transportation charge involved.

THE BRUSH DEVELOPMENT CO. **3405 Perkins Ave., Cleveland 14, Ohio**

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